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Effect of Urea or Urea- Molasses Treated Maize Stover on Body Weight Change and Carcass Parameter on Hararghe Highland Sheep, Eastern Ethiopia

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Abstract
This experiment was conducted to evaluate feed intake, daily body weight gain (ADG) and carcass characteristics of feeding sheep with a basal diet of untreated and treated maize stover (MS) at Haramaya University. The experiment was conducted in a randomized complete block design using 20 intact male Hararghe Highland sheep having a mean initial body weight of 15.4 ± 0.57 kg (mean ± SD). The animals were grouped into five blocks based on initial body weight and randomly assigned to four treatments; namely, untreated maize stover ad libitum (T1); urea treated maize stover (UTMS) ad libitum (T2); urea-molasses treated maize stover (UMTMS) ad libitum (T3 and T4). T1, T2 and T3 were supplemented with 300g concentrate mix of wheat bran (WB) and noug seed cake (NSC) at the ratio of 2:1. Hundred kg of maize stover (MS) was treated with 4 kg of urea dissolved in 100 liters of water alone or with additional 10% molasses. Water and block salt were available to the animal at all time. The crude protein (CP) content of MS, UTMS, UMTMS, NSC and WB were 5.9, 8, 10, 30.1, and 17.2%, respectively. Higher ($P<0.001$) total DM intake was noted for sheep fed T2 (700.7 g/day) and T3 (770.9 g/day) diets than those fed T1 (538.28 g/day) and T4 (481.4 g/day). CP intake was in the same trend as dry matter intake. ADG was 45.1, 65, 69.1, and 20.7 g/day for T1, T2, T3 and T4, respectively, which was significantly higher ($P<0.001$) for T2 and T3 than T1 and T4. Furthermore, T1, T2 and T3 animals had higher ($P<0.001$) feed conversion efficiency, dressing percentages ($P<0.001$) and hot carcass weight ($P<0.001$) than T4 animals. In general, animals in T2 and T3 had 1.5 and 3.2 times higher average daily gain than those in T1 and T4, respectively. Similarly, animals in T1, T2 and T3 produced about 2.3 kg more carcasses than those in T4. The result revealed that supplementing either urea treated or urea-molasses treated maize stover is a better option to improve both biological and economic performance of sheep. But, no advantage was gained from treating maize stover with a blend of urea and molasses solution if the basal diet is supplemented with concentrate diet.

INTRODUCTION

Small ruminants occupy an important economic and ecological niche in agricultural systems throughout the developing countries (Devedera, 2005). Also Small ruminants are important protein sources and cash income for many farmers in the tropics and sub-tropics. Among the small ruminants, sheep contribute a substantial amount to the farm household income, mutton and non-food products, such as manure, skin and coarse wool. Despite the immense contribution of sheep, their productivity in Ethiopia is low (FAO, 2001). Because, the productivity of indigenous sheep breeds is low as compared to temperate breeds due to limited genetic capacity and mainly environmental factors. Among the environmental factors, the main bottleneck for the small holder livestock production in numerous tropical countries like Ethiopia is the inadequate supply and low level of feeding due to serious shortage of feedstuffs. In Ethiopia, sheep are kept mostly on natural pastures, crop residues and stubble grazing in which the quality and quantity are subjected to great seasonal variation (Solomon *et al.*, 2008). In the mixed cereal livestock farming systems of the Ethiopia highlands, crop residue provide on average about 50% of the total feed source for ruminant livestock and its contribution reach up to 80% during the dry seasons of the year (Adugna, 2007). The scenario holds true in Hararghe highlands where limited areas of permanent grazing land are available and livestock depend upon crop residues and stubble grazing during the dry season.

Although the quality of these crop residues is limited due to their they make the bulk of the available feed to ruminants, their potential is limited by high fiber (>55% NDF), low protein (< 7%), low minerals such as sulphur, phosphorus and cobalt and vitamin content (Kayongo *et al.,* 1993; Seyoum and Zinash, 1995; Lopez *et al*., 2005; Ramirez *et al*., 2007). This shows that crop residues are deficient in essential nutrients necessary for efficient microbial growth, which leads to low rates and extent of digestion in the rumen (Gasmi-Boubaker *et al*., 2006), hence reduce feed intake and productivity of livestock when they are offered as a sole diet to animals (Adugna and Sundstol, 2000; Ramirez *et al*., 2007; Solomon *et al*., 2008).

Effective methods through which utilization of low quality roughages could be improved include supplementation with energy and nitrogen sources, chemical and/or physical treatment, and selection and breeding of crops, each of which ultimately depends on the economic benefits and applicability (McDonald *et al*., 2002). Supplementation of poor quality feeds with nitrogen sources increases the rate and extent of digestion resulting in improved dry matter intake (O' Donovan *et al.,* 1997). Non-protein nitrogen (NPN) sources such as urea and readily available energy sources such as molasses optimize rumen function. Treatment of crop residues with urea is particularly adapted to the needs of small farms and producers, and can be undertaken within a family without need for help from externally paid labor (O' Donovan *et al.,* 1997). Beyond improving the nutrient content, urea and urea - molasses treatment reduces loss of crop residue and consequently save the bulk which leads to improved utilization of feed proper to the feeding calendar (Rehrahie and Ledin, 2001). However, the potential of urea-molasses treatment in improving the nutritive value of maize stover, and thereby animal performance fed the treated stover was not sufficiently assessed in the country in order to make recommendation for wider use. The objectives of this study were: To evaluate the effect of urea or urea-molasses treatment of maize stover on live weight gain and carcass characteristics of Hararghe highland sheep.

MATERIALS AND METHODS

Study Area The experiment was conducted at Haramaya University goat farm. Haramaya University is located 515 km East of Addis Ababa at an altitude of 1950 meter above sea level at 9.0° N latitude and 42.0° E longitude. The mean annual rainfall and temperature of the study area are 790 mm and 16°C, respectively (Mishra *et al*., 2004).

Animals and Management: Twenty yearling intact male Hararghe Highland sheep having initial body weight of 15.4 ± 0.57 kg (mean±SD) were purchased from a local market. All sheep were quarantined for 21 days, and treated against internal and external parasites. They were offered the basal diet and concentrate mix for another fifteen days to get them acclimatized to the experimental feeds and procedures prior to the commencement of the actual experiment.

Experimental Feed Preparation: Maize stover used for the experiment was obtained from different varieties of maize grown and harvested in Haramaya University. The stover was chopped into 3-5 cm cuts using tractor mounted chopper. Four pits with a dimension of 2m x 2m x 2m were dug. A polyethylene sheet lined the floor and the sides of the pit. A solution of 4 kg of urea in 100 liters of water was prepared to treat 100 kg DM of maize stover (Dolberg, 1992). To prepare urea-molasses treated maize stover, 4kg of urea was added to 100 liter of water and stirred very well until urea is dissolved and clump of urea was disappeared from the solution. Then 10 liter of molasses was added and stirred very well until the molasses and the urea solution gets mixed up (Chenost, 1995). This solution was uniformly distributed and thoroughly mixed with chopped stover. The treated stover was placed in the pits which all sides were lined with clean plastic sheet and trampled with human foot to ensure proper packing. Following similar procedure, layers of such treated stover were placed until the pit was full. Then, the pits were covered from above with plastic sheet, compacted with soil and stone, and was left to incubate for 21 days.

Experimental Design and Treatments: The experiment was arranged in a randomized complete block design (RCBD) with four treatments and five replications. The experimental animals were grouped into five blocks of four animals based on their initial BW and each animal in each block was randomly assigned to one of the four dietary treatments in such a way that an animal in a block had equal chance to receive one of the treatment diets (Table 1).

Table 1. Diatary ingredients used in the experiment

Treatment		Supplement of concentrate mix/head/day
T1	*Ad libitum* untreated MS	300g
T2	*Ad libitum* 4 % urea treated MS	300g
T3	*Ad libitum* 4% urea- 10 lit/100kg molasses treated MS	300g
T4	*Ad libitum* 4%urea- 10 lit/100kg molasses treated MS	0g

MS: maize stover; concentrate mix consists of = 33% noug seed cake and 67% wheat bran.

Measurements and laboratory analysis

Body weight and average daily gain the initial body weights of experimental sheep were taken at the beginning of the growth experiment and at the interval of every ten days throughout the experiment. Average daily gain (ADG) was calculated as the difference between the final and initial BW divided by the number of feeding days. The feed conversion efficiency (FCE) was calculated as the proportion of ADG to daily DM intake of experimental animals.

Carcass parameters: All sheep were fasted overnight, weighed and then slaughtered. Empty body weight was determined by subtracting the gut fill from slaughter body weight. Dressing percentage was calculated both as a ratio of hot carcass weight to slaughter weight and empty body weight multiplied by 100. The rib-eye muscle area of each animal was determined by tracing the cross sectional area after cutting between 12th and 13th ribs perpendicular to the back bone.

Total edible offal (TEO) components were taken as the sum of blood, liver, kidney and kidney fat, heart, omental fat, abdominal fat, tongue, reticulo-rumen, omasum and abomasum, large and small intestine and tail.

Total non-edible offal components (TNEO) were computed as the sum of spleen, pancreas, head without tongue, skin and feet, genital organs (testicle and penis), lung with trachea, and gut content.

Statistical Analysis: Data analysis was conducted using the general linear model (GLM) procedure of Statistical Analysis Software (SAS, 2008) by fitting the fixed effects of dietary treatments and block. The treatment means were separated using Tukey HSD (honestly significant difference) test. The model used for data analysis was:

$Yij = \mu + ti + bj + eij$,

Where; Y_{ij}= the response of individual observation, μ= overall mean, t_i = treatment effect bj = block effect, e_{ij}= error

RESULTS AND DISCUSSION

Body Weight Change: Final body weight of sheep fed T3 and T2 was greater ($P<0.001$) than that of T1 and T4 Table2. Average daily body weight gain (ADG) was significantly ($P<0.001$) affected by treatments and it was higher for T3 and T2 than T4 and T1. Feed conversion efficiency was higher ($P<0.001$) for T3, T2 and T1 compared to T4. Differences observed in final body weight and consequently in ADG appear to be consistent with differences in nutrient intake and nutrient digestibility observed among treatments.

Table 2. Growth parameters and feed conversion efficiency of Hararghe highland sheep fed untreated, urea or urea-molasses treated maize stover basal diet supplemented with concentrate mixture

Parameters	Treatment				SEM	p-value
	T1	T2	T3	T4		
Initial BW (kg)	15.0	15.5	15.4	15.7	0.185	0 .2692
Final BW (kg)	19.0^{b}	21.2^{a}	21.6^{a}	17.6^{b}	0.361	<0.0001
ADG (g/day)	45.1^{b}	62.8^{a}	69.1^{a}	20.7^{c}	2.697	<0.0001
FCE (g ADG/g DMI)	0.084^{a}	0.089^{a}	0.089^{a}	0.042^{b}	0.0002	<0.0001

^{a,b} means within a row not bearing a similar superscript letter significantly differ. SEM= standard error of means;

Sheep fed sole urea-molasses treated stover (T4) exhibited the lowest ADG. Nevertheless, the positive gain in T4 indicated that stover treated with combination of urea and molasses improved the content of nutrients such as CP and energy in excess of the maintenance requirements of the animals. Van Soest (1994) demonstrated that body weight gain is impaired if the level of protein in a given diet is below 8%. Since the CP content of urea-molasses treated maize stover in the current study exceeded the minimum limit, the observed positive ADG of sheep is expected. In previous studies, feeding sole urea treated barley straw (Hadjipanayiotou *et al*., 1993) to Awassi sheep and urea treated maize stover to Hararghe highland sheep (Hirut *et al.,* 2011) did not fulfill the maintenance requirement, hence resulted in body weight loss. Thus, the positive weight gain of sheep fed with sole urea-molasses treated maize stover showed a considerable importance of this method of stover treatment in increasing the nutritive values of poor quality roughages. Thus, it may be used as a feeding strategy during the dry season to alleviate weight loses as a result of poor nutritional quality of the available straw.

The ADG obtained in T2 and T3 was in line with the value (63.8 g/d) reported by Tesfaye (2007) in sheep fed teff straw basal diet and supplemented with 350 g concentrate mixture. The growth rate obtained for sheep fed urea-molasses treated MS with supplementation in the current study was higher than the ADG values of 31.3, 47.2 and 54.4 g/day reported for Washera sheep fed urea treated rice straw supplemented with 300 g/day of noug seed cake and wheat bran (Hailu *et al.,* 2011), for Arsi-Bale lambs consumed urea treated wheat straw supplemented with 300 g/day of *Leucaena leucocephala* foliage hay (Getahun, 2014), and Hararghe highland sheep fed a basal diet of urea treated maize stover supplemented with 250 g/day of concentrate mix (Hirut *et al.,* 2011).

The body weight gain of T1, T2 and T4 in the present study was lower than the daily body weight gain (67.8 - 83 g/day) reported by Tsehay (2012) for Hararghe highland sheep fed natural pasture grass hay basal diet and supplemented with mixtures of onion leaves, noug seed cake, and wheat bran at different proportions. On the other hand, lower ADG (less than 21 g/d) were reported for Blackhead Somali sheep fed natural grass hay consisting between 9.2 and 9.9% CP (Wogenie, 2008). Awet and Solomon (2009) reported that supplementation of wheat bran with urea treated teff straw improved the efficiency of nutrient utilization of intact and castrated Afar sheep at 250 g and 350 g supplementation levels, which is in accordance with improved nutrient utilization and growth observed in groups fed basal diet of treated maize stover and supplemented with concentrate at a rate of 300 g/day. In general, in agreement with the present finding, previous studies reported increased ADG with increase in nutrient intake such as CP (Dawit and Solomon, 2008). Feed conversion efficiency (FCE) was higher ($P<0.001$) in T1, T2 and T3 as compared to T4. The improved FCE seem to be related to higher nutrient concentration in these treatment groups and the consequent increase in BW gain and better feed conversion efficiency. High protein and energy levels in the diet improves ADG and FCE of animals (Ebrahimi *et al*., 2007).

Carcass Characteristics: Carcass characteristics are shown in Table 3. Slaughter body and empty body weight was significantly higher in T2 and T3 than in T1 and T4, T4 having the lowest value than all other treatments.

Although T2 and T3 had higher nutrient intake and average daily gain as compared to T1, the hot carcass weight was only higher in magnitude (by 15%) as compared to T1. Thus, hot carcass weight (HCW) were similar among T1, T2 and T3 and was lower (P<0.001) in T4. Rib eye area (REA) were significantly higher for T2 and T3 (P<0.001) than T4. Such differences are related to variation in intake of digestible nutrients since improved nutrient availability enhance carcass yields (Archimede et al., 2008). Dressing percentage expressed as empty body weight were similar (P>0.05) among all treatments, while dressing percentage on slaughter weight basis took a similar trend like that of HCW. The dressing percentage on slaughter weight basis in the current study was in the range of 30.8 and 38.2%, which is comparable with the value of 32 to 40 % reported for Afar rams (Tesfaye, 2007), 32 to 41% for Adilo sheep (Biru, 2008) and 31 to 41% for Hararghe highland sheep (Hirut et al., 2011).

Table 3. Carcass characteristics of Hararghe Highland sheep fed untreated, urea or urea-molasses treated maize stover basal diet and supplemented with concentrate mix

Parameters	Treatment				SEM	p-values
	T1	T2	T3	T4		
Initial body weight (kg)	15.0	15.5	15.4	15.7	0.185	0 .2692
Slaughter weight (kg)	18.9^b	21.2^a	21.5^a	17.5^b	0.403	0.0002
Empty body weight (kg)	14.4^b	16.4^a	16.8^a	11.7^c	0.532	0.0003
Hot carcass weight (kg)	6.9^a	8.0^a	8.1^a	5.4^b	0.286	0.0008
Dressing % per SW	36.7^a	38.2^a	37.9^a	30.8^b	1.041	0.0221
Dressing % per EBW	47.9	49.0	48.2	46.1	0.592	0.2161
Rib eye area (cm^2)	7.5^{ab}	8.1^a	8.7^a	6.1^b	0.253	0.0107

$^{a, b}$ means in the same row with different superscript differ significantly; SEM = standard error of mean.

The increase in most of the slaughter parameters observed in the present study is presumably related to the more nutrient supply to animals due to supplementation and concomitant improvement in ADG. Increment in hot carcass weight with supplementation is commonly observed (Abebe *et al.,*2009), and is a consequence of improved growth rate associated with enhanced intake and digestibility of DM and nutrients, that might have lead to more nutrient availability for production. According to Forbes (1995), too low voluntary feed intake depresses rate of production resulting in the use of large proportion of the metabolizable energy consumed to cover the requirements for maintenance thereby reduced efficiency of feed conversion. Poor nutrition results in low rates of production and also affects the immune system and ability of animal to fight disease (ESGPIP, 2008). Thus, based on the results of the present experiment, treating maize stover with urea and urea-molasses could improve the nutritional status of the animal and give a positive return in terms of carcass yield.

Dressing percentages expressed on empty BW did not significantly differ among treatments. This could be associated with slight differences in gut fill of sheep in different treatments. The lack of significant impacts of supplementation on dressing percentage on empty BW basis have also been reported earlier (Abebe *et al.,* 2009), unlike other groups of studies that showed significant and positive effects of supplementation on dressing percentage (Tesfaye, 2008; Tsehay, 2012).

Rib-eye muscle area is an indirect measurement of body musculature and amount of lean meat in the carcass (Wolf *et al*., 1980). Rib eye muscle area is positively correlated with slaughter weight (Fernandes *et al*., 2008), and can be impacted by nutrition. Comparable results of rib eye muscle area (6.1 - 8.7 cm^2) to the present study, were reported by Abebe *et al.* (2009) for Arsi-bale sheep and by Hirut *et al.* (2011) for Hararghe highland sheep (3.7 – 8.4 cm^2) fed basal diet of urea treated maize stover and supplemented with increasing level of concentrate diet. On the contrary, Mulu (2005) reported larger rib-eye muscle area of 13-19.5 cm^2 for Wogera sheep fed natural grass hay and supplemented with graded levels of brewery dried grain.

Main carcass components (primal cuts) are presented in Table 4. For most primal cuts, the value was lowest for T4, while there was no significant difference between treatments in rib with muscle. Total main carcass component (TMCC) was significantly higher for T3, T2 and T1 than T4. Generally, the differences between treatments may be due to the differences in slaughter weight as it determines the relative weight of primal cuts (Galvani *et al.,* 2008).

Table 4. Main carcass components of Hararghe Highland sheep fed untreated, urea or urea-molasses treated maize stover basal diet supplemented with concentrate mix

Parameters	Treatments				SEM	p-value
	T1	T2	T3	T4		
Loin weight (kg)	1.16^{a}	1.31^{a}	1.32^{a}	0.85^{b}	0.072	0.0027
Forelegs (kg)	1.47^{ab}	1.74^{a}	1.75^{a}	1.14^{b}	0.074	0.0037
Hind legs (kg)	1.87^{b}	2.33^{a}	2.26^{ab}	1.45^{c}	0.096	0.0009
Brisket (kg)	0.75^{a}	0.85^{a}	0.87^{a}	0.49^{b}	0.061	0.0014
Ribs with muscle (kg)	1.00	1.15	1.15	0.94	0.05	0.1797
Neck (kg)	0.67^{ab}	0.78^{a}	0.79^{a}	0.55^{b}	0.049	0.0093

^{a,b} means in the same row with different superscript differ significantly; SEM = standard error of mean.

Non -Carcass Components

Edible offal components: In the present study, the weight of blood, kidney, heart, tongue and gut compartments were not significantly different (P > 0.05) among the treatments Table 5. This might be due to the fact that the weights of internal organs are more dependent on factors such as sex, breed and age of animals than plane of nutrition (Archimede et al., 2008). However, when the total edible offal components are considered, the effect of treatments was significant, being heavier for T3 than T1 and T4.

The effects of treatments on the weights of other edible offal components such as liver and internal fat components were apparent. The increase in liver weight with supplementation might be related to the storage of reserve substances such as glycogen (Lawerence and Fowler, 1998). The weight of omental fat of sheep fed T2 and T3 diets was significantly higher (P < 0.05) as compared to sheep fed with T1 and T4 diets. They also tended to have heavier weights for the other internal fat components. This may be due to the higher energy content of these treatment feeds that might have promoted higher internal fat deposition. Archimede *et al.* (2008) reported that differences in fat weights are correlated with plane of nutrition or energy content of the diet and appropriate dietary energy protein combinations. Therefore, differences in weights of some edible offal components in the present study may be attributed to differences in energy consumption of the sheep across treatments.

Table 5. Edible offal components of Hararghe Highland sheep fed untreated, urea or urea-molasses treated maize stover basal diet supplemented with concentrate mix

Edible offal	Treatment				SEM	p-value
	T1	T2	T3	T4		
Blood (g)	698.0	657.0	679.0	585.0	0.049	0.4065
Omental fat (g)	29.4^{b}	74.3^{a}	82.5^{a}	27.3^{b}	0.008	0.0032
Kidney (g)	60.7	55.3	56.0	38.1	0.003	0.1501
Kidney fat (g)	28.4^{b}	86.0^{ab}	92.9^{a}	27.0^{b}	0.01	0.0289
Liver (g)	251.2^{ab}	282.5^{a}	276.1^{a}	179.3^{b}	0.016	0.0531
Heart (g)	59.5	64.0	65.8	46.5	0.004	0.0663
Heart fat (g)	28.4^{bc}	37.0^{ab}	37.4^{a}	31.2^{c}	0.002	0.0129
Omaso-abomasum (g)	158.6	159.4	192.5	148.3	0.015	0.5455
Reticulo-rumen (g)	494.7	484.4	520.6	407.0	0.036	0.5271
Tongue (g)	54.3	61.5	55.0	54.6	0.002	0.3846
Large intestine (g)	400.0	394.0	406.0	275.0	0.034	0.5762
Small intestine (g)	150.8	159.0	192.0	148.0	0.015	0.335
Tail (g)	703.2^{ab}	815.9^{ab}	958.4^{a}	325.7^{b}	0.103	0.0397
TEO (kg)	3.1^{b}	3.4^{ab}	3.7^{a}	2.3^{c}	0.126	0.0006

^{a,b,c} means within a row not bearing a similar superscript letter significantly differ.-SEM= standard error of means

Non-edible offal components: The average weights of non-edible offal components are shown in Table 6. There were no significant differences (P<0.05) among treatments for all parameters considered except for penis fat and testis. In agreement with the current study, Hirut *et al.* (2011) noted supplementation to have no impact on most individual and total non-edible offal components.

Table 6. Total non-edible offal components of Hararghe Highland sheep fed untreated, urea or urea-molasses treated maize stover basal diet supplemented with concentrate mix

Edible Offal	Treatment				SEM	p-value
	T1	T2	T3	T4		
Gut content (kg)	4.47	4.62	4.72	5.74	0.252	0.1626
Feet (g)	419.89	472.03	452.52	396.14	0.019	0.4088
Skin (kg)	2.02	2.19	2.19	1.98	0.115	0.2908
Spleen (g)	22.51	27.12	28.67	19.70	0.003	0.231
Gall bladder (g)	11.07	12.52	27.48	19.96	0.005	0.2902
Lung with trachea (g)	248.57	285.47	284.72	218.99	0.02	0.3743
Head without tongue (g)	1.14	1.48	1.35	1.13	0.071	0.1103
Penis fat (g)	84.80[b]	122.39[a]	79.72[b]	54.34[b]	0.007	0.0031
Testis (g)	146.40[a]	242.25[a]	236.21[a]	138.44[b]	0.022	0.0565
Urethra (g)	21.28	12.22	78.39	18.49	0.032	0.4073
TNEO (kg)	8.63	9.59	9.45	9.73	0.26	0.4037

[a, b]Means with different superscripts in rows significantly differ. SEM= standard error of means;

CONCLUSION

Treating maize stover with the blend of urea and molasses solution relatively improved growth performance and meat yield of Hararghe Highland sheep when fed as sole diet compared to feeding untreated stover. Thus, the result of the present study indicates that the feed value of treated maize stover when supplemented with concentrate mix is promising and can be used as alternative feeding technology to increase growth rate and carcass production of sheep in areas where crop residues are being dominantly used as animal feed. The result also implies that urea-molasses treatment of maize stover is promising to maintain animals' body weight in the absence of supplementation.

REFERENCE

Adugna Tolera, 2007. Feed resources for producing export quality meat and livestock in Ethiopia (Examples from selected Weredas in Oromia and SNNP regional states).

Adugna Tolera and F. Sundstol, 2000. Supplementation of graded levels of *Desmodium intortum* hay to sheep feeding on maize stover harvested at three stage of maturity. Feed intake, digestibility and body weight change. *Animal Feed Science and Technology,* 85: 239-257.

Archimede, H. P., Pellonde, P. Despois,T. Etienne and G. Alexandre, 2008. Growth performance and carcass traits of Ovin Martinik lambs fed various ratios of tropical forage to concentrate under intensive conditions. *Small Ruminant Research, 75*: 162-170.

Awet Estifanos and Solomon Melaku, 2009. Supplementation of Graded Levels of Wheat Bran to Intact and Castrated Afar Sheep Fed Urea Treated Tef Straw: Effects on Feed Intake, Digestibility, Body Weight and Carcass Characteristics. *East African Journal of Sciences,* 3 (1) 29-36.

Biru Kefeni, 2008. Effects of supplementation with sweet potato tuber and haricot bean screenings on feed utilization, growth and carcass characteristics of Adilo sheep. An M.Sc. thesis Presented to the School of Graduate Studies of Haramaya University. 73p.

Chenost, M., 1995. Optimizing the use of poor quality roughages through treatment and supplementation in warm climate countries with particular emphasis on urea treatment. FAO, Rome.

Dawit Abate and Solomon Melaku, 2008. Effect of supplementing urea treated barley straw with vetch (*Vicia dasycarpa,* L.) or alfalfa (*Medicago sativa 'Hunter River'*) hay on feed intake, digestibility and growth of Arsi Bale Sheep. *Tropical Animal Production and Health.* DOI 10.1007/s11250-008-9227-1, 41:579–586

Devendera, C., 2005. Small ruminants in Asia: contribution to food security, poverty alleviation and opportunities for productivity enhancement. In: Ledin, I. (ed.), Proceeding of International Workshop on small ruminant production and development in South East Asia, MEKARN, Noug.lam, HCMC, Vitenam. 19-32 p.

Dolberg, F., 1992. Progress in the utilization of urea-ammonia treated crop residues: biological and socio-economic aspects of animal production and application of the technology on small farms. *Livestock Research for Rural Development*, 4 (2).

Ebrahimi, R., H. R. Ahmadi, M. T. Zamri and E. Rowghani, 2007. Effect of energy and protein levels on feedlot performance and carcass characteristics of Mehraban lambs. *Pakistan Journal of Biological Science,* 15(10): 1679-1684.

ESGPIP (Ethiopian sheep and Goats Productivity Improvement program), 2008. Sheep and goats production handbook for Ethiopia, Branna printing enterprise. Ethiopia. 345p.

FAO (Food and Agriculture organization of the United Nation), 2001. Mixed crop-livestock farming: a review of traditional technologies based on literature and field experience. FAO Animal Production and Health Papers 152, Rome, Italy. 129p.

Fernandes, M.H.M., K.T. Resende, L.O. Tedeschi, J.S. Fernandes, Jr., I.A.M.A. Teixeira, G.E. Carstens and T.T. Berchielli, 2008. Predicting the chemical composition of the body and the carcasss of ¾th Boer x ¼th Saanen Kids using body components. *Small Ruminant Research,* 75: 90-98.

Forbes, J. M., 1995. Voluntary Feed Intake and Diet Selection in Farm Animals. CAB International, Wallingford, UK.66p.

Galvani, D. B., C. C. pires, T. P. Wommer, F. de oliverira, A. M. S. Bolzan and P. Francois, 2008. Carcass traits of feedlot crossbred lambs slaughtered at different live weights. ciencia Rural, Santa Maria. 38(6): 1711-1717.

Gasmi-Boubaker, A., C. Kayouli and A. Buldgen, 2006. Feed blocks as a supplement for goat kids grazing natural Tunisian rangeland during the dry season. *Animal Feed Science and Technology*, 126: 31-41.

Getahun Kebede, 2014. Effect of wheat straw urea treatment and *leucaena leucocephala* foliage hay supplementation on intake, digestibility, nitrogen balance and growth of lambs. *International Journal of Livestock Production,* 6 (4): 88-96

Hadjipanayiotou, M., L. Verhaeghe, A. R. Kronfoleh, L. M. Labban, A. Shurbaji, M. Amin, A. R. M. Erawi, A. K. Harress, M. Houssein, G. Malki and M. Dassouki, 1993. Feeding ammoniated straw to cattle and sheep in Syria. *Livestock Research for Rural Development*, 5 (1):30-38.

Hailu, A., Solomon, M., Berhan, T. and Asaminew T. 2011. Body weight and carcass characteristics of Washera sheep fed urea treated rice straw supplemented with graded levels of concentrate mix. *Livestock Research for Rural Development,* 23 (8).

Hirut Yirga, Solomon Melaku and Mengistu Urge, 2011. Effect of concentrate supplementation on live weight change and carcass characteristics of Hararghe Highland sheep fed a basal diet of urea treated maize stover. *Livestock Research for Rural Development,* 23 (12).

Kayongo, B.S., M.M. Wanyoike, N.P. Mubgua, E.T. Maitho and N.P. Nyaga, 1993. Performance of weaner sheep fed wheat straw ensiled with caged layer waste. pp. 131-136. In: proceeding of the Second African Feed Resources Network (AFRNET) Work Shop held in Harare Zimbabwe 6-10 December 1993. Sustainable Feed Production and Utilization for Small Holder Livestock Enterprises in Sub-Saharan Africa.

Lawrence, T. C. J. and V.R. Fowler, 1998.Growth of farm animals.CABI publishing, London. 271-273 P.

Lopez, S., D. R. Davies, F. J. Giraldez, M. S. Dhanoa, J. Dijkstra and J. France, 2005. Assessment of nutritive value of cereal and legume straws based on chemical composition and in vitro digestibility. *Journal of the Science of Food and Agriculture,* 85: 1550-1557.

McDonald, A.A., R.A. Edwards, J.F.D. Greenhalgh and C.A. Morgan, 2002. Animal nutrition, 6th ed. 187-198 p.

Mishra,B.B., H.G. Kidan, K. Kibret, M. Assen and B. Eshetu, 2004.Soil and land resource inventory at Alemaya University research farm with reference to land evaluation for sustainable agricultural management and production. Synthesis of working papers, Soil Science Bulletin No.1, 123 p. Alemaya University, Dire Dawa, Ethiopia.

Mulu Moges, 2005. Effect of feeding different levels of brewery dried grain on live weight gain and carcass characteristic of Wogera sheep fed on basal diet. An M.Sc. Thesis presented to the School of Graduate Studies of Alemaya University. 54p.

O'Donovan, P B., Soomro F M., Wagenaar J P, Shafiq-ur-Rehman, Farhat Abbas and Bukhari 1997. Urea treatment of straw: a farmer - friendly system improved upon in Balochistan 1997 9 (5), Retrieved on 2010.

Ramirez, G.R., J.C. Aguilera-Gonzalez and G. Garcia-Diaz, 2007. Effect of urea treatment on chemical composition and digestion of *Cenchrus ciliaris*, *Cynodon dactylon* hay and *Zea mays* residues. *Journal of Animal Science and Veterinary Advance,* 6 (8): 1036-1041.

Rehrahie Mesfin and Ledin L 2001.Bilogical and economical evaluation of feeding urea treated teff and barley straw based diets to crossbred dairy cows in the highlands of Ethiopia. M.Sc. Thesis. Swedish University of Agricultural Sciences, Department of Animal Nutrition and Management. Uppsala, Sweden.

SAS, 2008. Statistical Analysis System, version 9.1, Institute, Inc., Cary, NC, USA.

Seyoum Bediye and Zinash Sileshi, 1995. Influence of variety and location on feeding value of barley straw. pp. 312-315. Proceedings of the 3rd Annual Conference of the Ethiopian Society of Animal Production held in Addis Ababa, Ethiopia. 27-29 April 1995.

Solomon Bogale, Solomon Melaku and Alemu Yami, 2008. Matching livestock systems with available feed resources in the Bale Highlands of Ethiopia. *Outlook on Agriculture,* 37 (2): 105-110.

Tesfaye Hagos, 2007. Supplementation of Afar rams with graded levels of mixtures of protein and energy sources: effects on feed intake, digestibility, and live weight and carcass parameters. An M.Sc. Thesis presented to the School of Graduate Studies of Haramaya University. 82p

Tesfaye Negewo, 2008. Effect of supplementation with graded levels of wheat bran and noug seed cake mixtures on feed utilization of Arsi- Bale sheep fed urea treated maize cob basal diet. An M.Sc. Thesis presented to School of Graduate Studies of Haramaya University, Haramaya, Ethiopia.

Tsehay Regassa, 2012. Effect of graded levels of onion leaves as a substitute for wheat bran in concentrate mixture on performance and carcass characteristics of Hararghe Highland sheep. An M.Sc. Thesis presented to school of graduate studies of Haramaya University, Haramaya, Ethiopia.

Van Soest, P. J., 1994. Nutritional ecology of the ruminant.2nd ed. Cornell University, London. 244-252 p.

Wogenie Birhanie, 2008. Effects on increasing levels of energy and protein supplementation on feed intake, body weight change and carcass composition of Blackhead Somali sheep fed on grass hay. An M.Sc.Thesis Presented to School of Graduate Studies, Haramaya University, Ethiopia. 23p.

Wolf, B.T., C. Smith and D.I. Sales, 1980. Growth and carcass composition in the cross bred progeny of six terminal sire breeds of sheep. *Journal of Animal Production,* 31(5): 307-313.